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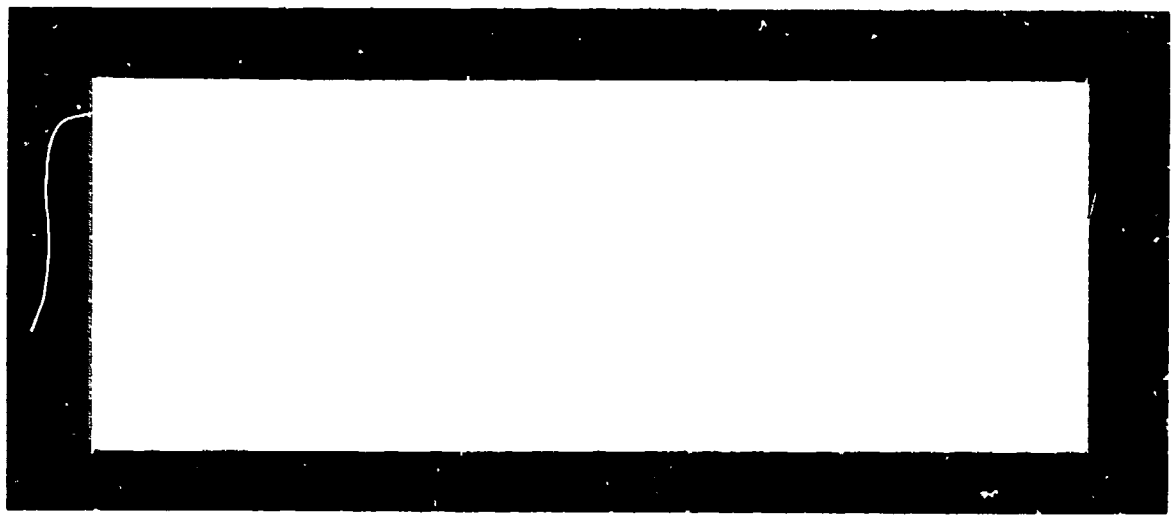
ABSTRACT

A keynote address for the Commission on Teacher Education of the National Council of Teachers of Mathematics Forum on Teacher Education, this paper briefly discusses what the author considers the major broad issues of both mathematics education and the education of mathematics teachers. Problems are outlined without a particular effort to propose solutions. Topics covered include the mathematical competence of teachers, the mathematics curriculum, methodology, the teacher as manager of the classroom mathematics instructional system, the teacher as manager of a student group, evaluation, the affective domain, integration of mathematics with other disciplines, research, mathematics teaching as a profession, and fiscal responsibility. (JM)



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MATHEMATICS EDUCATION REPORTS

ISSUES IN MATHEMATICS EDUCATION

James F. Gray, S.M.

National Council of Teachers of Mathematics
Forum on Teacher Education
Chicago, Illinois
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ERIC Information Analysis Center for
Science, Mathematics, and Environmental Education
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PREFACE

In planning the 1972 Forum on Teacher Education, the Commission on Teacher Education of the National Council of Teachers of Mathematics commissioned a keynote address from James F. Gray. This paper was prepared for that address. Because it speaks to broad issues in mathematics education as well as to mathematics teacher education, we are pleased to make it available to a wider audience as a Mathematics Education Report.

April, 1972

Jon L. Higgins
Associate Director for
Mathematics Education

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ISSUES IN MATHEMATICS EDUCATION

James F. Gray, S.M.

In thirty years of teaching and talking mathematics, I have never felt as diffident as I do in presenting this paper.

Picture to yourself a country musician who got to be quite good on his guitar -- who learned by himself, but learned readily, played easily and well, enjoyed his playing and found that others enjoyed it also, so that he was in frequent demand to play for people. Inevitably, and uncomfortably, the TV talk shows got hold of him and he was made to talk about his music -- and was very much ill at ease doing so, obviously not nearly the artist as raconteur and musical analyst as he had been at simply strumming. Bad enough -- you've all seen this on television many times -- but not nearly so devastating as the day he suddenly (without quite realizing how he got in this position) found himself outlining the entire field of musicology and music education to a small group of people, including a number of Leonard Bernstein's and Arthur Fiedler's.

When I was first asked to make this presentation, I demurred. I told the inquirer I was sure that he could get someone much more ideally suited to it. However, knowing how many no's appear to requests like this before a yes can be found and thinking rather simplistically about speaking informally to the needs of teachers rather than formally to the world of mathematics education, I assented when he pressed me.

Much of my diffidence comes from the fact that I am not nearly as much embedded in the technical world of teacher education as most of you are. I am essentially a secondary mathematics teacher who happened to complete a doctorate in mathematics. Thirty years of teaching everything from fifth grade to graduate school mathematics has made me aware that I play the guitar (classicists please excuse) of mathematics teaching rather well. I enjoy it as I enjoy nothing else, and my students -- including the teachers I share with -- seem to enjoy it as well. I have essentially approached mathematics teaching as art rather than science. My work with the "new" math was to teach it to teachers and to assist teachers to learn it and then teach it themselves. Discussing mathematics teaching and its problems in the systematic and scientific way that many of you customarily do was, for me, quite tangential to the doing of it.

While I readily accepted workshops and talks for all kinds of teacher groups, my practice was to present some topic in mathematics itself and make my commentary to the teachers on education, methodology, or curriculum through the materials I chose and the concrete manner in which I presented them. I resisted, not always successfully, but usually so, requests to talk "about" mathematics. So it is that I find myself very amused at myself to be here outlining to you the overall and fundamental issues of mathematics education.

However, ever prone to rationalize, I have finally identified a number of factors that make this role at least somewhat meaningful for me.

First of all, I still identify myself more as an on-going mathematics teacher rather than a member of the mathematics education establishment. As such, I hope, I can speak from a feeling of the needs of a teacher about what important expectations I have for teacher education and what are the issues of meaning to me -- rather than speaking from the point of view of an involved, and possibly somewhat partisanly committed, member of an on-going educational operation, possibly deeply embedded and enamoured of one area of turmoil such as educational research, curriculum developments, evaluation, systems organizations, etc. For certainly the purpose of such a Forum as this is to be responsive to reality -- the real needs of teachers and students for the future -- rather than to the exposition of categories to which we have previous vested interest or intellectual commitment. While I am sure that many of you have well kept balance and perspective and have not become one-sided participants in the problems of education, I no longer feel (as I once did) that my lack of high recent involvement in the technical problems of teacher education might be a handicap to key-noting the salient issues.

A second reason for feeling more at home about this presentation is an acceptance of the fact that I am not going to say anything startling, earth-shaking, revolutionary -- and that such is really not my role. The problems of education are monumental, but not always romantic. Crisis in the Classroom and The Greening of America have already played the role of emotional stimulants to arouse concern, however inchoate, about the general health -- apparently mental as well as physical -- of the American educational patient. My job as a working intern is merely to record some of the obvious symptomatic issues and to note once again evident exterior signs that deal with constrictions in breathing, slackness of pulse, local tenderness, etc. When it finally dawned on me that you gentlemen would be the Dr. Welby's of the day, I relaxed almost completely. I have listed some of the obvious trouble spots, the issues, the areas where symptoms indicate something awry. But you all must make the diagnoses, whether startling or prosaic, interpret the symptoms, agree or disagree with the relevance of any particular one of them, flesh out the list of problem areas if your intern missed any, and possibly discard some of the ones that he has listed as not really that relevant to the fundamental health problem of a patient in crisis in too many other ways.

Finally, after using a medical model to take myself somewhat off the hook, I turn in the third place to the inevitable -- a computer model. I think this Forum is one of the most significant events in mathematics education in many years. I have long been prodding the NCTM, especially in days past as Chairman and member of the

Instructional Affairs Committee, about the need for agressive action in the field of teacher education. I was most happy to see the Council turn its resources and its most appropriate presence seriously toward these problems. But, again, my long time concern over the magnitude and complications of this whole area, and its greatest significance to the future of mathematics education has added to my diffidence at being responsible for a key role in this important Forum in the state of my own rather extensive bankruptcy in the area of solutions to current problems of teacher education. It is only the realization that the Forum is to eventually provide the output, the direction, the beginning of a response and that I am responsible only for an input, a triggering of the Forum, that has put me back at ease. I have come to view my role as the prosaic one of First Approximation. Like many a mathematical process prepared for computer solution, as its first approximation I can be even rather far from the mark without ultimately spoiling the final solution -- the ultimate outcome that you people, as the processing unit, will review, scan, sort, reformulate, reject, synthesize and tailor into a relatively polished, sensitive, accurate output that will be the fruit of many memory and logic units, format processes and sophisticated language endeavors working together to forge a meaningful program. As a First Approximation my input can be quite prosaic (like the number 4), even though the ultimate result desired might be both romantic, mystical and relevant (like e or π). Further, I can be brief (briefer than I have been up to now) for the sooner one makes the first approximation and tosses it into the pot, the sooner the computer can get started on the real work ahead. If so, having rationalized my role from that of an olympian egghead with ready made answers to that of a Simple Simon, I come to you with some everyday observations of a teacher -- and what he sees as issues for the education of people like himself.

This statement need limit nothing, but only mark a beginning which you all will then extend, modify, edit, add to, and assign priorities within, that you will structure in the light of your specialties, do battle over and come to conclusions about.

Issues in Mathematics Teacher Education

Rather than begin with highly specific issues, which could be readily multiplied and which would vary in magnitude, I have elected instead to take issue-areas -- areas in which the teacher education establishment must make some definite response to the needs of mathematics teachers everywhere, and concerning which responses there are a number of particular problems and questions.

A. Mathematical Competence of Elementary and Secondary Teachers.
B. Mathematics Curriculum for the Schools.
C. Methodology.
D. Teacher as Manager of the Classroom Mathematics Instructional System.

E. The Teacher as Manager of a Student Group.
F. Evaluation.
G. The Affective Domain.
H. Integration of Mathematics with Other Disciplines.
I. Research.
J. (Mathematics) Teaching as a Profession.
K. Fiscal Responsibility.

A. Mathematical Competence of Elementary and Secondary Teachers.

Mathematics Teacher Education (MTE) must provide a mathematics teacher with competence in mathematics. Perhaps the greatest necessary (though certainly not sufficient) condition for good mathematics teaching is the possession oneself of sound and adequate competence in mathematics. Medieval philosophers summarized a number of fundamental insights by Latin clichés, one of which I still recall and which is applicable here: Nemo dabit quod non habet. No one gives what he doesn't possess. While this is not completely true -- we can often help others find things that we do not have ourselves -- one has a hard time teaching or guiding the mathematics student without adequate mathematical competence oneself. Teachers must have a thorough mastery of the mathematics they need to teach as well as of the mathematics they need to give perspective to their teaching.

Not only is it simply that the absence of such knowledge makes it difficult to transmit it to students. It is only in the security of high competence that a teacher feels sufficiently free to himself proportion this mathematics to the needs of his students without feeling bound by the particular packaging of the text book, his teachers' notes, or other prepared materials which do not exactly fit the particular situation of his students. In the security of truly understanding what he is about, the teacher can consider his situation, his students' needs, and his mathematical objectives and go about his own strategies for the accomplishments of these objectives.

So our first concern, our first issue, is a very prosaic one. It is one about which much has been done already, but which perennially remains of major importance in spite of its seeming prosaic nature. Constantly of importance, and never finally resolved are questions like: What should mathematics teachers know? What curricula offerings must be designed for them? What overall programs? The work of CUPM has been particularly monumental in this field and has produced great strides forward in the mathematical competence of teachers by the early publication of recommendations for the training of mathematics teachers. But this is no place to rest on laurels. The topic continues to be important and the latest revisions by CUPM witness to this. Many questions remain about these curricula offerings. Good as the CUPM recommendations are, are they satisfactorily weighted by the needs of the mathematics teacher community itself? Has NCTM been sufficiently active

and contributory in this area? How can it help the programs of teacher education to be more relevant in mathematical content?

Despite their increased realism, mathematics programs for future or in-service teachers are still reluctant to differentiate possibly as much as they should between intense efforts to produce mastery of a certain core of fundamental materials highly relevant to the actual mathematics needed by elementary and secondary teachers and a more low-pressure approach to the background, perspective, and overview of mathematics that are certainly necessary to the mathematics teacher's conception of the whole wide world of mathematics but which are not going to be operational needs of his in any remote sense in his teaching function. It took many years for the early NSF programs to overcome an overly puristic profile. CUPM recommendations have moved further in the direction of realism. But many individual courses are still taught to teachers in a way that leaves them with a vague and badly garbled knowledge of the entire content of the course rather than being pitched in such a way that the teacher has a sound and thorough knowledge of the fundamentals, topped off by an overview of the remaining structure -- all of which might make more sense in the long run. This certainly remains an issue for any on-going commission on teacher education.

A related issue that no one seems to have contended with seriously and that is a challenge to the mathematics education establishment is to devise some way to deal with the teachers of mathematics courses intended for teachers. We all know that a very relevant course in linear algebra for secondary school teachers, given the same syllabus, the same textbook, the same amount of time, the same relative teaching conditions, can be anything from an enjoyable, revealing, stimulating, and confidence-building experience to an utter and desolate disaster consisting of the repetition of meaningless days and purposeless hours in the classroom. What can be done to help the many mathematicians who teach these courses to accept the need to become better teachers of them, to accept an obligation for results where the burden lies on them to do at least as well as some of their colleagues do, rather than a burden that is transferred almost completely to the future teachers as seated in their classrooms?

B.B. Peterson's recent article in the Monthly makes the most courageous and cogent plea I have yet seen to the university and collegiate mathematics community to face and to respond to this problem of the teaching of undergraduate and teacher-oriented graduate mathematics.

B. Mathematics Curriculum for the Schools.

Mathematics teacher education must help provide mathematics teachers with a sound and a relevant curriculum in mathematics for the

schools. In the last decade or two, much of the interested mathematical world was concerned with curriculum construction and teacher training in the light of the new curricula. And amazing things have been accomplished and a great amount of social change produced in a relatively short space of time. It is obviously time to turn our attention to many other issues, as Jerome Bruner so ably notes in 'The Process of Education' Revisited in the September, 1971 Kappan. While this is true enough and we have taken great strides in the area of mathematics curriculum, there are many strides to go yet before nightfall. Now that we have learned to stride in this direction, it would be silly to stop striding, to sit on a rock and think only about our other problems. We can continue to stride forward while addressing these other problems. The mathematics curriculum gains of these years should be reviewed, consolidated, revised, updated, and expanded. With the lessons learned from SMSG and others about curriculum development and implementation, new projects should be forthcoming in a more efficient and efficacious manner conserving the momentum of the past without so absorbing the energies of the mathematical community that it cannot gear up to an equally creative attack in the many remaining problems of mathematics education which are much more subtle and much more recalcitrant than the curriculum problems.

A particular issue that should be of some concern to the mathematics educational community is metrication. It is a very concrete and particular problem. Without being a momentous problem, it is one of great magnitude for the country. The need is obvious, the direction inevitable. Yet, I understand that all of the committees working away at this problem have pointed to education rather than industry or government as the key to metrication. Particular though this problem may be, it is pervasive and fraught with many consequences and gives up a real opportunity to again display the power of the mathematical community to produce effective change in its field of competence.

C. Methodology.

At a Forum such as this, one senses an unexpressed desire for the new, the avant garde, the exciting, that which is magnificent in scope, magical and insightful. I wish I could honestly join the people who manage to get such instant notoriety, like Ivan Illich with his simple proposition that the greatest need of education or the greatest concern for educators should be to de-school society. However, the only image that posture brings home to me is the picture of a teen age boy who so lacks the motivation, the creativity, the discipline, the energy to clean his room at home that he ends up pitching a tent in the back yard.

I would like to tell you that one of the big needs of education would be for a massive pentagonesque institute in Washington, D.C. cramme with wall-to-wall computer which would run all of the country's education on a systems management and CAI-oriented approach. Or I would like

to be able to tell you that I really believed one of your biggest concerns would be to work with NIH to develop a massive program of innoculation with RNA-related memory-transfer material contributed by the best mathematical minds of the country.

Unfortunately, my next suggestion as an area of concern for you as math educators, is the need of mathematics teachers themselves for plain old fashioned prosaic methodology.

In this day when there is so much talk of the teacher as a manager of the classroom instructional system, and where the preparation of a teacher is being geared to a future school world that sounds like a technical Disneyland, I am still concerned in aiding the teacher to become as versatile and as effective as possible as a simple presenter of mathematics.

I am in no way disturbed by the fact that education is preoccupied with the preparation for the future and visualizes a future which in many ways is almost utopian from an educational point of view. I am very interested in the current thrust of futurology.

But I do have the impression that the world of teacher education has gotten to be so preoccupied with preparing for some future world, many of whose capabilities presently exist, that they are insufficiently aware of the need to prepare teachers for the present and real world which they find about them as they enter the teaching profession and which they will continue to find about them for many, many years ahead.

Futuristic elements must be present in a teacher education program. Young people, absorbing these thrusts, will be the ones who fulfill the prophecy. But many of them never have the chance to make this contribution because the world that they enter in the teaching profession is so far different from the theoretical models they are prepared for that they don't have the proper survival techniques and operational know-how to root themselves in their profession and establish a platform from which they can help guide that profession into the twenty-first century.

Educators by and large are intrigued, not only by the future, but by those rare and exciting prototype examples of new procedures and projects which seem to be creating the beginning of the future at the present. And quite often, their education courses seem to be preparing all teachers to teach in a Nova school despite the fact that these teachers will actually begin teaching in Public School No. 47, in some traumatized urban situation. Even, it seems to me, many of the programs apparently oriented towards the preparation of teachers for the current inner-city school systems somehow end up preparing the teacher to run inner-city schools the way the theorists think they are and should be in some future time rather than to enter as they are now and convert them to that future.

At any rate, my chief point here is that no matter what the common future pattern will be of the teacher as manager of an educational system or learning facilitator, there will be a majority of schools for many years yet in which the majority of the teachers will be chiefly responsible for the clear and effective presentation of mathematics to large groups of students. Hence continued attention to methodology -- to the art and science of such presentation -- remains a necessary and very important area of concern for mathematics education. In a certain sense there is no future; every future moment will then be a present. It is rather ironical to almost entirely abandon our contemporary present in order to prepare for some future present. The two I think can be wedded.

Medicine gives us some good analogy here. For all the attention that is put on futuristic medicine in the development of our doctors and of the medical profession itself, there is an evident and recognized need for current practitioners to function now, in today's hospitals and dispensaries, and often far from the highly developed medical centers, with practical personal knowledge and flexibility rather than the utilization of a complex man-machine system that is capable of doing such marvels in the right setting.

Although the last decade of penetration into the mathematics curriculum also found a great deal of work being done, insights gained, artistry developed in the area of the presentation of these curricula materials, it remains very important to continue and extend this art and science of presentation, and to communicate the best of it to new generations of teachers.

The teacher education world is challenged to provide the new teacher with as much of a science of methodology as it can. They are challenged to attempt to get the future mathematics teacher to function as an artist, as one who has an independent confidence in his understanding of mathematics and of his students so that he can best, and flexibly, arrange what is done in the classroom to the achievement of objectives. This very skill in the presenting of mathematics is the preliminary qualification for the ultimate role of the teacher -- some today, many more tomorrow -- as a manager of a classroom instructional system.

The world of teacher education is already doing excellent things in this area.

Many courses, high level programs of student teaching and internship, various uses of video taping in the student teaching process, and similar practices have helped the teacher immeasureably to become a practitioner, an artist in his field.

In any field of art, broadening horizons of the novice is one of the contributions that professional development through formal programs

provides in contrast to merely topsy-like self-development. This broadening must be more than the mere theoretical classification of a multitude of methods and approaches. There must be a real push to practice, to try out the varied and different, so that each teacher can find his best mode of expression, can surface hidden talents, can develop his own style of mathematics presentation.

One of the stimulating sides of this particular Forum is the interest taken in identifying, recording, and disseminating innovative practice in mathematics education. The multitude of newer challenges, more futuristic sounding developments, and the promise of a computer in every classroom and a console in every cottage, should not cause us to falter in our continued creative development of improved methodology for current mathematics teaching and better ways of sharing this with our teachers of both the pre-service and in-service level.

Here we have made some inroads into recording and sharing some of the innovations favored by various teacher education programs. I feel there still remains a tremendous challenge in striving to identify in the actual on-going mathematics classrooms of the country, creative and ingenious methodology, whether innovative or ancient, which is effective, insightful, productive and replicable. How shall we find these? How shall we evaluate them? How shall we communicate them?

D. Teacher as Manager of the Classroom Mathematics Instructional System.

While many classrooms across the country, for many years yet, will still feature the self-contained teacher trying to optimize the communication of a certain segment of mathematics within the self-contained classroom to a homogeneously group and paced class of students, increasing numbers of teachers in classrooms have been affected and continue to be affected, at least in some measure, by another virus. In what I'd attribute, or at least relate, to the Harold Howe tenure in the Office of Education, the role of the teacher as store house and intermittent transmitter of mathematical culture gave way of some real necessity to the concept of the teacher as one who managed an instructional system, who served as facilitator and coordinator of a rather diversified process of achieving particular objectives of mathematical education.

The pressure of highly differentiated individual needs, the creation of varieties of programs to present individually prescribed instruction, whether computer assisted or not, the involvement of a multi-media approach to the pursuit of mathematical objectives, increased reliance on independent study and many probing questions about the teaching-learning process put such pressure on the self-contained teacher teaching in the self-contained classroom that increasing

attention was given to the systems concept in education, not only on the gross scale of the organization of the overall school system, but even within the operation of a single mathematics classroom. Emphasis on the need for specificity of objectives, and a strong emphasis on behavioral objectives, and with a greater richness of proposed avenues for achieving these objectives in the rapid proliferation of a wide variety of educational materials, and computer assisted instruction undermined the concept of teachers as single and sole sources of mathematics for students. It cast the teacher in a role broader than that of merely clarifier and communicator. He is required to consider himself as a manager of this classroom instructional system. It required the teacher to be concerned for the identification and specification of particular mathematics objectives for the group, or better yet, differentially, for the individuals within the group; to be broadly aware of the different strategies available for attaining these objectives and the relative suitability of each; to have some acquaintanceship with a wide variety of prepared materials using various media that might contribute to the achievement of the objective specified; to be able to select and coordinate the usage of a variety of these available materials within the selected strategy for the accomplishment of the goals; to provide feedback, evaluation and remediation. All of these things highlighted a managerial decision process that only remotely resembled the previously required second-nature responses of the experienced teacher.

That every teacher be a sophisticate in the jargon and deep theory of a systems approach to education is utopian. And it is not really necessary. But there is enough of what is good and needed in the available diversified approaches to the teaching-learning process today that the teacher must have some pragmatic feeling for this new role of manager of the classroom educational system.

At an age when identity and self concept (or rather the lack of these) lie behind so many particular ills of society, it is no small thing to ask teachers to assume a new, demanding, and quite divergent role of educational manager in a somewhat technical sense of the term. One of the challenges of the teacher education establishment ahead is to provide some concrete and practical help to the teacher on the pre-service or in-service level to help him or her understand and have some practical familiarity with the demands of this role of educational manager. Some reasonable and understandable composite of simple systems theory with practical exemplification and actual laboratory experience seems indicated. Some exposure to the demands and potentialities of each phase of the system operation is indicated. Some time spent on the importance, the productivity, and the problems connected with a specification of particular objectives in mathematics; some acquaintanceship with the wide spectrum of rich strategy available to attain objectives; some close contacts with the media possibilities in today's world and some of the unique advantages of particular media for

certain types of goals; some acquaintanceship with the richness of prepared mathematical materials and some criteria for discernment amoung these as to quality, usability, and relevance to the objectives in mind; the need for and means of evaluation; the creativity needed to read the evaluation and take practical remedial action for the cases in which objectives have not been sufficiently fulfilled. Just the simple service of making sure each new graduate in mathematics education has the security brought by the familiarity with the machinery and gadgetry of our multi-media world is a challenge.

However, the real challenge is that of role acceptance -- to have the teacher truly look upon himself as the manager, the coordinator, the faciliatator of the learning experience as opposed to the teacher concept sewed in his subconscious mind by the teacher roles he has seen in the past. The challenge to teacher education is to do this at the pre-service level and, with even greater difficulty, to somehow provide an in-service approach to the existing teachers who have already solidified their present self-image and role perception as teacher over years of experience and to get them to broaden and extend this role perception to encompass the managerial functions that increasing numbers of them will have to assume in the years ahead.

To what extent is it valid to say that the newly prepared teacher must have the expertise in a systems approach to the mathematics classroom? How can this background be imparted? How can the mathematics education community clarify for itself the concept of the mathematics classroom as instructional system? How far should it go in this direction? How simple or how complex a description would suffice? How can the role-change of the teacher be brought about?

E. The Teacher as Manager of a Student Group.

Helping a teacher to acquire the attitudes and expertise necessary for him to function as manager of a mathematics classroom instructional system is a difficult, though somewhat clear-cut, task. The problem of aiding the teacher to become an effective manager of a student group, a facilitator, a communicator, is a wholly different problem even more gigantic in magnitude and far from clear-cut.

The school as the orderly and authoritarian institution that we once know is increasingly hard to find. The pressures put by a complex and confused society on an alienated and self-assertive generation have lead, on the one hand, to the rejection by theorists of the rigid and highly-disciplined traditional school, and, on the other hand, to the de facto impossibility of maintaining many such schools in the midst of student unease and related problems of school sociology.

Student action, student rights, student disaffection with the school, its teachers, its curriculum, its ultimate goals for them are mounting and massive forces.

The student who is coming to school is a whole person -- often a new kind of person -- who insists on spending his whole day as such -- as an "I" to the teacher's "Thou", in terms of one of today's familiar philosophies. With the usual pendulum swing, we find theoretical school models and living exemplars which feature a permissive antipodal to past rigidity -- but which are just as sterile for educational productivity and for human growth. Young teachers, part of their generation, enter the fray convinced their love alone will conquer all -- and shortly fall victims of their own simplicism and deprive our profession of some of it's finest recruits.

A great issue for teacher education, and indeed despite its generic nature, for mathematics teacher education, is how to prepare the teacher to cope with the human expectancies levied at him by a new race of young people.

A recent ACT publication, "When We Listen, This Is What We Hear..." finds the voices of young people telling us that what they want from teachers is that they be concerned (as expected) and demanding (a surprise?).

What can we do to provide students with the kind of persons they need as teachers? How can we help pre-service teachers prepare themselves for the demands thrust on them by a generation in upheaval? What in-service efforts can we mount to help teachers already formed and often sometimes even rigidified by years of experience to make this same adaptation to a new generation? I am sure that the answer does not lie in a school model which is in the simplicity of either end of the rigidity -- permissiveness scale, but rather somewhere in the complexity of the middle of this scale. I also feel that we must screen for and cultivate teachers whose profiles contain strong peaks in the area of concern for students as persons and of willingness to make demands on students for productive effort.

Were I a fledgling teacher today, I know I would want some help from the teacher education establishment that would: 1) give me some insight into the turbulent youth of today; 2) equip me with some practical group dynamics to handle a class full of such youngsters; 3) differentiate these dynamics sufficiently to suit the teaching-learning situation and its goals rather than an encounter session or a group theraphy session; and finally; 4) provide me with some feeling that my professional group was actively working -- by research, prototype exploration, conceptualization, group pressure -- at making over schools into the kinds of enviornment which could not be alien to what that same teacher establishment had led me to believe in and embark upon the practice of.

It is in this whole area of concern that we face the major challenges of mathematic education today.

It is here that we must face the issues of individual differences and the considerable problems of offering equality of mathematical opportunity to every one and of setting mathematical goals for various students that differ only in the light of personal capacity. It is here we must face the problem of the slow learner, to the extent that it is truly a problem of slowness of learning, as well as the needs of the talented, where recent outcries indicate that we have been far less active than we should be.

But beyond the difficult questions or proportioning mathematical opportunities of individual students, it is in this area that we face the major social problems of mathematics education today.

We have a massive challenge in extending equal mathematical opportunities to all groups despite wnat may seem to be handicapping cultural and social background factors. We have to honest enough to avoid cutting back on the equality of opportunity for mathematics education because of a variety of social or cultural difficulties that we will encounter. We must delve into the creative development of programs that will overcome the difficulties these varied cultural and social factors have put in the way of mathematical literacy for all, and, instead of changing our goals, improve our performance.

It is in this area, also, that our profession must exhibit an openness to any promising educational innovation that seems to have a reasonable chance of effecting solutions to basic teaching problems that have made little progress through standard approaches. Specifically, I think that we must keep a truly open mind on the possibilities of performance contracting. By this I do not mean that we must abandon an excruciating and rigorous scrutiny of every phase of every performance contracting endeavor in the mathmatics field. If anything, we should increase our monitoring interest in this whole field. But it should not become a political position decided ahead of time, nor a negative advocacy position but one of openminded enthusiasm for trying to help create, if it is truly possible in this area, a viable education machinery that will do a better job than in the past.

Previous NCTM Committees have been attempting to come to grips with communication workshops to develop increased human relations skills and communication skills to be utilized by teachers in working with groups of students. Despite the many obvious problems connected with extreme models in this area, I believe these probes are to be highly encouraged. Some varieties of communication and human relation skills are essential for our mathematics teachers. The American Association of School Administrators has recognized this in a resolution being proposed to its 1972 Convention which reads as follows:

"The ability to make and carry out decisions on the basis of a scale of values that gives human beings priority over material objects, position and security makes a citizen a rare asset to his community. AASA recognizes that relatively few people exercise this ability effortlessly -- but its use can be learned. All school personnel need a specialized body of human relations knowledge. We recommend, too, that school districts sponsor human relations programs for educators, students, parents and community and civic representatives. As a provision for the future, we urge that human relations education be provided students of education in all colleges."

F. Evaluation.

There is no area more in need of courageous and imaginative attention from the mathematics education community than the area of evaluation. The world today is drowning in production. Production is no longer accelerating to satisfy unfulfilled needs, but rather needs are being created to utilize large scale and poorly specified production. Education shares in the general problems of this pollution.

I think it would be profitable to consider what I might call our Gross National Education Product (GNEP) on an annual basis. I would think of this GNEP as the true total educational growth of the country within a year. It would seem to be a dependent variable that is the function of many things but chiefly four more or less independent variables; students themselves, teaching-learning systems and theories, teaching materials, and teaching personnel.

Pollution and/or production touches all four of these independent variables today. We are living amidst a population explosion that has given us problems of student sociology never before encountered. Teaching and learning theories, projects, experiments, ranging from fads to the well-founded, abound on all sides supported by government, professional associations, university research, and even local community initiative. The most familiar area of overproduction lies in the field of teaching materials with the hardware explosion an obvious one, tightly bound to a problem of relevant software. First there was an outcry of concern that software production lagged so far behind the related hardware capabilities. Now we are even more horrified to find the software production surging mightily, but with a tragic indiscrimination, to close the gap. Lastly, teacher overproduction has brought us to the threshold of a major crisis.

In all of these areas of overproduction rare nuggets of excellence are buried amidst an avalanche ranging from adequate to poor.

The greater this overproduction grows the more an individual educational practitioner needs some grounds for discrimination in his choice of materials, procedures, approaches -- the more he needs help from the educational community in the way of evaluation.

And the roles of evaluation with respect to the various independent variables mentioned above, and consequently the evaluation philosophies, techniques, and priorities, will all vary considerably. With regard to students, the evaluation must be concerned with identifying their needs and planning responsive programs to remediate these needs. The world of evaluation has never really caught up with the student explosion, the questions of cultural bias and available testing, the monumental work involved in criterion-referenced testing, and questions concerned with the affective as well as cognitive development of individual students. A world of challenge lies here. How can the mathematic education establishment, with the keen insights, its unique closeness to teachers and students provides for it, guide the specialized work of evaluation to be constructive, creative, and responsive to these imperative needs?

The hardware-software production and interplay is a familiar and obvious problem. Mechanical and electronic equipment, together with audio and video tapes, film loops, manipulative materials, projectuals, have gone into a multi-million dollar industry. With all the pressure of the world about them being placed on teachers to get change and technological progress, the need to move and to utilize new hardware and software becomes imperative, matched only by the general inability to comprehend, analyze, and select from the mass of overproduction those hardware devices and software developments which are truly functional and helpful, which are truly excellent and authentic. How does the mathematics educational establishment mass its forces to give the needed evaluation of these many items? How does it assure an open mind and a fair hearing while at the same time giving some leadership to teachers, some endorsements of obviously good materials and approaches? How is any concensus gained concerning highly controversial items amid a community whose thrust for professionalism is at the same time enriched by a great diversity of viewpoints, attitudes, and theories about what is educationally good?

I think NCTM is to be highly praised for the attempts it has made to grapple with this massive problem in some positively constructive way by its columns in the Mathematics Teacher wherein are reviewed new products, new programs, and new publications. Just as obviously, these provide by scattered landmarks in a gigantic wilderness. The problems are ticklish, but the need to face them great. As vanishing educational dollars are noisily quarrelled over, they are becoming too precious to misspend on meaningless hardware or invalid software -- to say nothing of the precious moments spent out of the lives of many students and teachers enmeshed in ritual dances with meaningless materials.

Now let us look at another wilderness -- that of the production of teaching and learning methods and approaches. Manufacturers at least spend some moments of thought before they commit money and resources to the production of a line of educational materials. It is much harder on the one hand to produce a coherent, viable, creative new approach to teaching or learning a certain portion of mathematics -- at least for responsible people who are really concerned with the validity of what they are doing. On the other hand, it can also be very easy for people to create new ideas, new approaches new claims for various teaching strategies, without cost, off the top of their head and to become very aggressive and often persuasive in getting other people to adopt or follow these as magic solutions. Sincerity here is no guarantee of excellence. And, if ever there is a complex field for evaluation, it lies in attempts to assay the effectiveness or the conditions under which there might be effectiveness to a certain approach to teaching or learning, whether it be a massive and grand theory or a procedure calculated to serve in a very restricted area. (This issue is referred to again under the separate heading of research in connection with teaching and learning theories.)

Finally, the whole field of teacher evaluation is both politically touchy and educationally difficult. It presents a special challenge, again to the mathematics education establishment since most of the members of that establishment who must try to guide the assault on this increasingly important area are themselves non-objective by the very fact that they too for the most part, are teachers of mathematics in some sense of the word. But evaluation is obviously necessary. Some of the political and other aspects of this question are touched on in the issue entitled "Professionalism."

We described GNEP as a function of four major independent variables and suggested the great complexity but even greater need for the evaluation of various elements of the replacement sets of these variables, with an eye to an optimal range for these variables.

A major task, certainly ultimately related to the four evaluation challenges just issued, is the need to attempt some evaluation of GNEP (Gross National Educational Product) itself. The National Assessment Program is one such attempt that demands the support and concern of the entire mathematics educational community. I think the reason for the word "support" is self evident. But our concern is also needed so that the mathematics education community can make it.

How can we better become involved with, serve, and upgrade the mathematics portion of the National Assessment Program?

Beyond evaluation, but an issue I consider so dependent upon the results of good evaluation that I treated here rather than separately, lies the question of dissemination.

Once we have identified truly good or helpful teaching materials, hardware or software, teaching practices or approaches, that give evidence of being effective in a particular context, how can we best convey this information to the large mass of mathematics teachers who are anxious and willing to adopt and implement valid and well-recommended practices even though they themselves do not have the necessary creative capacity to originate such?

Let me close with a number of comments taken from remarks of P. Kenneth Komoski, President of the Educational Products Information Exchange Institute (EPIE) as they appeared under the heading "Pupils Seen as Victims of Untested Programs" in Education, U.S.A. September 13, 1971 (page 9). He says that a majority of U.S. schools may be using mediocre materials simply because no one has bothered to check their effectiveness. He contends that "the largest single group of unprotected consumers is made up of 50 million school children now required to use thousands of inadequately evaluated educational materials by schools each year." An EPIE analysis of 60 current "best selling" textbooks has revealed that fewer than 10 percent have ever been field tested prior to publication, and in House Subcommittee testimony, he pointed out that comments of salesman and consultants seems to be a major source of "field testing" for many firms. He felt that field testing of films and video broadcasts and programmed instruction materials were in more dismal shape than for textbooks. He argued "today's teachers and students do not need an ever increasing quantity of options. What they need desperately are high quality alternatives to the inadequately developed materials they are now required to use." He went on to take the wind out of educational sails by noting that educators are often poor judges of the effectiveness of learning materials and quoted one study in which the correlation (-.75) between teacher and principal-judgements and the actual performance of materials was "strikingly unsuccessful." He pointed to some positive developments, specifically by the Southwest Regional Laboratory for Research and Development, as a result of continual field testing and revision, but notes that the magnitude and cost of such enterprise is so great as to probably be a matter feasible only to something like the proposed National Institute of Education.

The whole question of evaluation has some serious implications for the teacher education institution itself. A modern astronomy course does not give equal time to the Ptolemaic and the Copernican theories of astronomy. One is treated by a passing commentary and the other is adopted with professional judgment as worthy of extensive time and study, as reflecting best reality for today's students.

In our teacher education courses, do we display for the students, with great impartiality and olympian detachment, dozens of different approaches to the teaching equally with the many facets and implications of these theories, carrying away no real convictions about the validity or uniqueness of any one of them, as well as no real

in-depth expertise in any one of them? Or do we have the courage to reflect our value judgments (evaluations) of these entities, and help our students to find and develop familiarity with a few of the more porductive and meaningful approaches? True, we do not have the ease of choice between the obviously outmoded Ptolemaic astronomy and it's more pertinent Copernican successor. But, because the choice is more complicated and more subject to an occasional error, this does not mean that we are excused from attempting to make an evaluation, attempting to exert leadership, attempting to say that, at least in some sense, our discipline has enough of the objective about it that we can indicate some preference for excellence among the multiplicity of shopworn models.

G. The Affective Domain.

One of the keenest challenges of the times faces mathematics education in the affective domain where we have long and determinedly avoided facing many problems.

The world of mathematics, with its relatively clearcut objectives, its fairly logical development, its rather easily tested programs has long been the envy of other educational subject-matter areas where concensus on goals, concensus on content, concensus on methodology, concensus on how and what to test for have been extremely complex and difficult in comparison to the analogous problems in the world of mathematics. At least this was all true in the realm of cognitive objectives.

On the other hand, we have not at all fared well in the affective domain. Elementary high school algebra was the long standing "freshman frankenstein". Older people commenting on past educational experiences that were at best meaningless and at worst highly unpleasant. Bright, intelligent people unabashedly described themselves as turned off by mathematics and many steady, hard-working types admit to being actually traumatized by it. And this reaction seems to apply to all levels of mathematics from early elementary school through the college mathematics courses.

We have had at our doorstep, then, for many years an extensive problem in the affective domain. How can we address ourselves to some of the important objectives in this domain: to get people to attend to mathematics, to respond to it, to value it, to organize and express themselves, at least in facets of their lives, in accord with it? How can we help them to enjoy and participate in their mathematical education experiences instead of merely submitting to or fighting through them?

While there might seem to be some general correlation between facility at doing mathematics and attitudes towards it, I have some serious doubts as to how strongly such a correlation would hold up.

Many facets of our mathematics teaching process, if not of mathematics itself, have tended to turn off the talented as well as the non-talented. What is it about mathematics--or, perhaps, more precisely--about our mathematics education approaches that tends to turn off people? What can we do to turn them on?

One of the saddest experiences that I have witnessed occurred some years ago in a university context and revealed a disastrous negative correlation between astonishingly high effectiveness in the cognitive mathematical domain and a complete fiasco in the affective domain. An experimental mathematics class for college freshmen with high talent, carefully selected under the tutelage of a graduate professor, penetrated deeply into a highly abstract course in modern algebra that out-stripped many a first-year graduate course. The approach was almost brutally honest from a mathematical point of view--at least, if all one hoped to gain was success at the cognitive level in mathematics. All burden was put on the students, little help was given, little teaching was done; it was a sink or swim situation. Most of these bright and talented students came through as technically highly successful. They read, delved, studied almost entirely on their own to conquer, and thoroughly conquer the mathematics involved. They succeeded excellently and, as freshmen, had not only a greater grasp of abstract algebra than most first-or second year graduate students, but a real perception of mathematics, the mathematics process, the mathematical mode of working. Also, except for a very small number, they ended up with an almost avid hatred of mathematics as a discipline and clearly expressed intentions to take no more of this subject. These proud and talented young people had refused to bow to the almost awesome intellectual challenges flung at them in the course and had met all of the cognitive objectives set for them, at a terrible expence of their own energies, but had done it in a setting that produced no love or appreciation for mathematics, but a sort of vengeful pride--like a man who is able to brag about walking through Death Valley and surviving where most have died, but who also resolves never to approach the desert again.

It is not merely the slower and steadier students that have been turned off by mathematics education at times. A whole past history of mathematics education cries out to us to turn our serious attention to the affective domain and to try to find some answers, some programs, some approaches, that will exploit the very specific mathematical qualities of our discipline to achieve the response, the valuation that we would like our students to place on it, that would give them the inner motivation to learn mathematics effectively through an appreciation of its many beauties and a love for its many attractions. It's not a simple solution we seek here. The above example illustrated a case in which it was possible to learn <u>more</u> mathematics but like it <u>less</u>. It would be easy to redress the situation, by a simple abandonment of standards, so that we could that we could like it <u>more</u> through

learning less. But our work in the affective domain should be geared to learning more mathematics through liking mathematics more.

Not only is it important for the mathematics education community to turn its attention to the affective domain in order to redress a long historical weakness in the math education field. There is a more pressing reason. The cultural changes going on at the present time have moved the interest of our younger generation away from the fields of mathematics, science, and technology and to areas of the social sciences and even further into the arts and humanities in their more sensuate and concrete form, rather than in their abstract side.

The qrowth of permissiveness, the increased reluctance of students at all levels to buy either the packaged curriculum programs of educators, or to accept the disciplines necessary to acquire competence in a demanding area like mathematics merely because it is an expectation of an older generation, of parents, of school, officials, is squarely before us.

While mathematics is increasingly becoming involved in a significant way with a wider and wider swathe of disciplines all necessary to a growingly complex modern world, the modern student is becoming more and more reluctant to expend the energy to master a mathematical discipline unless he sees in it some intrinsic meaning and motivation.

The Queen of the Sciences has all of the requisite beauties and charms, but of her unlike her more gaudy sisters, it can be said that the beauty of this king's daughter is often within. The beauty is there, but it's not an obvious and sensate beauty but a subtle and intellectual one. Our Queen of the Sciences needs some experienced beauty operators to do for her some simple things that will help let this beauty shine forth. We need some serious analysis of what and how we can exploit various facets of the nature of mathematics to achie desirable educational goals in the affective domain for our discipline.

H. Integration of Mathematics With Other Disciplines.

Another prime area of concern for mathematics education is the relationship of mathematics to other areas in the educational process. In an age where departmentalism is decried and curricular integration or intradepartmentalism is a common plea, one may think that there is no real issue here at all to discuss. Perhaps I am a captive of my own past, but I feel very queasy when I hear extreme models discussed in which mathematical course boundaries cease to exist and mathematics appears only in a complex setting interwoven in some seldom specified but apparently highly integral way with a number of other disciplines.

Certainly all educational compartments have been too tight. But what does one do about this? Is mathematics in any way uniquely different and exempt from some of the interdepartmental thrusts that are justified for other areas? Although I am no strong exponent of it, I am quite comfortable with the thought of the combined natural science course in which the year goes on with an interweaving of threads of chemistry, physics, biology and astronomy. If I were a physics teacher (again, for I was at one time), I would see little problem in integrating the mathematics I wanted to teach into my physics course and teaching it even if this was the one and only time that material was to be taught in a high school experience. But I still must confess myself uneasy at the reverse of this. As a mathematics teacher I have some hesitation about feeling that I would want to interrupt my math course to interweave a physics presentation, and entertain some serious doubts as to whether or not the mathematics course would be enhanced or the physics done justice. What is theoretically desirable here? What is really practical? Does mathematics have any uniquenesses or exemptions?

Certainly the question of thorough-going integration is a difficult and complex one and deserves the attention of our mathematical community. Even if such a thorough integration is not an answer, the question of the liaison between mathematics and any of the other areas is important and subject to serious concern on our part. A great deal of work has already been done on the interface between mathematics and science and between mathematics and computer science, and both of these areas deserve a continued preoccupation. We need to be much more aggressively and creatively involved in these dialogues. But additional possibilities lie before us.

Some years back I fought patient battles with the college bureaucracy to cross from the School of Arts and Sciences to the School of Business to provide a high quality business management minor for some of my math majors who were so interested and who rejected the usual physics or other natural science minors. I also managed to get the business school to approve a high-level mathematics minor for some of its business majors rather than the alternate specialized field of business or accounting. This is quite commonplace now at the college level.

But curriculum integration at the secondary level and the exploding presence of ungraded schools at the elementary level, raise a number of questions about relationships between mathematics and business, mathematics and the social sciences, and even the mathematics and humanities for elementary and secondary education. The mathematical education community should certainly assume leadership in developong guidelines and approaches that will aid in the inevitable development of these liaisons. One of the interesting examples of

what can be done in this area lies in the Engineering Concepts Curriculum Program (ECCP). Many other probes into interdisciplinary experiments are possible and worthy of exploration.

I. Research.

A major concern for mathematics education today is the role of research in providing solutions to the educational problems we face and orientation to the constructive developments that must be selected and pursued from among the many-branched pathways of the multivariate educational universe. Issues of all kinds arise in connection with both the theoretical role and the actual performance of research on behalf of educational progress.

Much that is good has arisen in the world of research in mathematics education recently. And here I use research not merely in the simple sense of constructing experiments to investigate hypotheses, but in a broad enough sense to include the construction and verification of theories of learning and of instruction. The recent preoccupation with research specifically in the area of mathematics education is a healthy sign. Another is the productive work of the former Research Advisory Committee of NCTM which eventually led to the excellent sessions on research at so many of Name-of-Site and annual NCTM Meetings over the last few years. The publication by NCTM of Piagetian Cognitive-Development Research and Mathematical Education is a symbol of the excellent and creative work being done in this field.

Nevertheless, the world of educational research, and even of mathematics education research, is involved with problems of information explosion and overproduction. At least the cry is frequently raised about the difficulty of maintaining high quality amidst the volume of such educational research. Further, from a world where enlightenment is badly needed about good educational practice, repeated challenges assert that research is insufficiently related to the ultimate educational consumer, that instructional implications are not found nor communicated.

It seems to me that there is a very different dynamic working in the relationship between research, the consumer, and funding in the world of education than there is at work in the world of industry. In the world of industry vast sums are dedicated to basic and apparently only remotely practical research; but in a very real way--an ultimate dollar-and-cents way--the industry demands eventually an accountability in pay-off by the research effort for the industry. Hard-nosed guidelines make demands that research projects, despite their remoteness, have ultimate meaningfulness for the industry in

question. Despite some obvious misses, the actual payoff on research investment is more than economically justified. Funding is provided for strong ultimate expectation of more than adequate return on that funding. Funding seems to expand in relationship to the inner viability and meaningfulness of the research proposed.

In the world of education, ultimate accountability by the industry for the productive outcomes of research has not been nearly so strong. The very source of funding--from outside the industry via government or foundation spending--lessens the inner strength of this accountability. In education, it seems to me that research tends to expand to fill the available money rather than money expanding to subsidize promising research, as seems to be the industrial model.

At any rate, there are a number of key issues for the mathematics education community. How can it help to guide and relate the current highly energetic thrust of mathematics education research to the high priority needs of the consumers, the people in the classroom situation? What kind of productive interdisciplinary liaison can be established to aid in blueprinting needed basic and applied research?

After good research has established, to some degree, the validity or preferability of a certain educational practice or principle, how can the mathematics educational community practically make use of this knowledge to package for classroom usage, useful versions, implementations, and approaches that flow from this research result? How can a prototype be best set up and tested? How can successful prototypes be appropriately disseminated on a large scale throughout the practicing educational community in massive classroom usage?

How can the mathematics teacher education community expand and make more effective its role as middle personnel or mediators between the researchers themselves and the classroom practitioners who should ultimately benefit from the fruits of good research? They are ideally situated to be able to talk to both of these remote worlds, and to interpret one of them to the other, to translate the needs of the practitioners for answers to certain questions into research suggestions for the trained people; they are also ideally suited to translate the findings of the researchers into practical suggestions for classroom implementation.

The research reporting at the NCTM meetings noted above is certainly an example of the healthy thrust in this direction and yet the imperatives are so great here and the chasm so vast that the issue remains of pressing concern to the entire mathematics educational community. A recent article in Educational Technology by

Robert D. Tennyson and M. David Merrill, "Hierarchical Models in the Development of a Theory of Instruction: A Comparison of Bloom, Gagne, and Merrill," talks about the "....need for basic research in developing an instructional theory...". The article makes an extended distinction between learning theory, where some satisfactory progress has been made, and a theory of instruction which is felt to be an even greater need, but a much more poorly developed area. Even the feelings of security that we are beginning to have in the area of learning theory itself, from the work of Piaget, have recently been shaken by some serious challenges to the validity of that work. How strongly should our thrust shift from concern for learning theory to concern for teaching theory. Should we not be the leaders in this development?

J. <u>(Mathematics) Teaching as a Profession</u>.

One of the burning, broad, pervasive, highly relevant issues of today is the status and ethical level of teaching as a profession.

The medical and legal professions have managed to keep a very high professional image. Much as we tend to speak of our work as the teaching <u>profession</u>, we must face the fact that in the public eye, and often in our own eyes, we are a profession in claim only, or at least not considered seriously to be a profession in any of the same sense that is readily granted to medicine or law.

Ethics and quality stand out as serious concerns of both of these other professions. Active steps are taken to preserve them against shoddy practice. Hard data and difficult criteria are the basis for admission into the ranks and later performance therein.

Yet these professions provide only sporadic help to the person in particular crisis of physical health or legal need. Our profession is concerned with long term and fundamental relationships with the young; it centers about elements of their personality and identity much more sacred than those treated by doctors and lawyers and much more all-pervasive and determinative of their whole life orientation.

Surely the quality and self-respect of teaching as a profession should exceed by far these aspects of medicine and law.

Yet we have no real beginning of self-policing, of screening entering or current membership. Every mention of merit recognition or performance criteria for teachers brings heavy protective reactions.

The challenge of bringing the teaching profession to an impeccable level superior in its quality to either medicine or law is a severe one. Questions of entrance and apprenticeship, of ongoing membership, of adequate performance, of merit, of separation honestly faced and managed are a must. The mathematics teacher education community must take the role in bringing these problems before the teaching profession, especially before young teachers. It must be prepared to speak at any special requirements that entrance into or continuation in of the mathematics profession, in particular, might require.

A world of changing educational need, where our only hope is for schools to be communities of students and teachers, demands to my mind the creation of other professional models than those currently espoused either by NEA or its emerging competitors. The focus on external power rather than internal strength and discipline by many of the organized professional teaching agencies seems to me to need an almost direct reversal. Integrity, austerity, and quality on the inside and a cooperative confrontation of the joint educational problems on the outside seems a necessary backdrop to the challenges that are massing before American education in the years ahead.

In particular, I find the readiness of teachers to entertain the possibility of a strike or similar sanctions as a deplorable weakness of our overall professional approach.

I have no qualms about respecting the strike, in its early origins, as not only a very moral but an absolutely necessary tool to turn around society in a number of ways in the area of social justice. But I think the presence of a strike in most situations in today's society is as outmoded and has as little place as the old western gunfight might have in one of our city streets today. In an enclosed subsystem that essentially is a simple labor-management dyad where a strike's principal and practically only impact is to make its point with management, I think there is little quarrel with the strike as a tool. But modern American society is so complex that it is practically impossible any longer to isolate a labor-management dyad into a sufficiently closed and remote subsystem that would limit the major impact of a strike to the interior of that system without major effects on the outside. Because of these widespread negative effects that strikes in most modern settings have on the innocent bystanders and on the many other facets of the community, and with the much more sophisticated legal, civic, and social machinery available today to bring about dialogue, conference and adjudication of difficulties it seems to me that the strike is like a prehistoric dinosaur which has lived beyond its time, but has not yet recognized its own death. To the extent that this insight is true and that other modes of dealing with labor-management

disputes must and are necessarily coming about, it is regretable to see the sudden upthrust of strikes and similar activities in an area such as teaching, where the most damaged ploys in the dispute are the young bystanders to whom society and the teaching profession both give such extensive lip-service.

Again, then, one of the fundamental challenges of the age is to collaborate and even provide the leadership to the reconstruction of teaching as a profession which is as highly authentic and ethical in itself, and in its public image, as any of the other professions.

Further, the mathematics education community must work to raise the level of the specifically mathematical teaching profession. Support and cooperation with professional organizations in this area such as NCTM, MAA, AERA is a must. The collaboration of the mathematics education community with a strong and creative agency such as SMSG which gave every evidence of strengthening professionalism in mathematics teaching is a response we can be proud of. Change of direction from the relatively simple problems of curriculum to the more complex problems that face mathematics education and today seem to indicate a greater support of the Conference Board of the Mathematical Sciences as a meaningful professional entity which is in an appropriate position to go beyond the boundaries of the individual mathematical agencies and coordinate a number of essential thrusts of the mathematics education community. I think we must strongly support the concept of a National Institute of Education and make sure that there is a great input from the mathematics education community and an active evaluation by the mathematics education community of the output of such an institute.

Particularly obvious is the need for the mathematics education community to actively attempt to better link the supply and demand curves for mathematics teachers at all levels and to exert some damping influence on the delayed and over-reactive pendulum effect that is taking place in the number of people entering the mathematics profession.

Apart from merely assuring a sane balance of numbers needed and numbers prepared, the mathematics education community must address itself to the problem of quality entrants into the profession. Law and medicine already do much more in this area than we do. We have made strides in demanding mathematical competency--at least more so than before--of many of our entering teachers, but we have no serious screening device with respect to some of the other important--even more important--qualifications for a good mathematics teacher discussed in this paper.

Further, the mathematics education community has a great deal of force to bring to bear on the whole area of credentials and certification. First of all, are the present credentialing and certification practices broad enough and strong enough to reflect many of the concerns we have been discussing here? Further, is the reciprocity of certification as yet satisfactory? Are good teachers ruled out on flexible, technical requirements? Are undesirable teachers easily admitted because substantive requirements are missing or are too easily waived?

In mathematics we have done many excellent professional things that are the awe of other disciplines. But these have generally been professional endeavors that lean to the mathematical side of teaching mathematics to students. We have been somewhat less aggressive and willing to confront problems in areas of ethics and quality, in areas that deal with the students, rather than mathematics, in the mathematics teaching situation. This side of our profession has many challenges to us for growth.

K. Fiscal Responsibility

Last summer I spent a busman's holiday at an AASA-National Academy Seminar on Evaluating Innovations. In the course of it, one of the speakers called attention to what he labeled the Balmol Crunch. He explained that this was a cataclysmic event that would take place in about 1984 if things continued on as they are now going.

It is the point at which, if gross national product continues to increase at its current rate and total educational expenditures in the country continue to increase at their present rate, the two curves will cross. In other words, if nothing changes the Balmol Crunch will occur on the day on which we spend our entire GNP for education. Obviously, that isn't going to happen. People will just refuse to spend that much money for education in the light of all their other needs and real or artificially stimulated desires in today's affluent society.

The point is that despite the many valid needs we still see in the world of education in general and mathematics education in particular, where monetary expenditures seem essential to progress, the whole educational spending spree has reached such proportions that built in limiting processes seem to be already in action. A number of issues face us here. First of all, we must realistically gear up to the implications of the cutbacks in available monies as already felt throughout the mathematics community at all levels

from graduate research to prototype programs at elementary schools. Part of the recent concern of the business meetings of both AMS and MAA has been resolutions addressed to NSF expressing concern at curtailment of monies addressed to needs of various phases of the mathematical community.

After having lived for many years in a particularly affluent segment of an affluent educational enterprise, we must realistically face the implications of fund shortages.

We must also avoid the simplicistic power thrust of an unqualified desire for more educational funds and begin to accept some civic responsibility for the implications that lie behind even a suggestion of a possibility such as the Balmol Crunch.

Attention to some of the already discussed issues (particularly the responsible evaluation of the expensive educational materials that are pouring into the market place) will help stem foolish spending at a national level. This honest avoidance of foolish spending may help provide funds for creative spending on true needs and viable solutions. Here again the leadership of the mathematics community in designing priorities for this creative spending and carrying the case for them is a challenge and a concern. In a world of budget cuts and money shortages, we must be prepared to carry the message both to government and to our own institutions as to the most meaningful choices in the use of the dollars available to us.

Conclusion

Here I have shared with you some thoughts on what I feel are major areas of concern for mathematics education. Most of them are directed at services the mathematics education community must render to individual teachers; some refer to concerns for the profession itself.

There is no pretense to completion in their list. I may well have missed your own favorite issue. Though personal bias and my own hopes for certain developments are reflected in some of the commentary, I had no thought to propose solutions.

My commission, and my purpose was to key-note this Forum by giving an individual input, obviously to be limited and subject to many shortcomings, that would start you all, a central, elite, and dedicated segment of the mathematics teacher education community, to work.